



**Assessment of Mercury Issues  
Resulting from Its Use in  
Small Scale Gold Mining (SSGM)  
in Dimembe District (North Sulawesi)**

March 2002



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The NRM Program's Policy and Planning Group supports cross-cutting policy analysis and institutional development and provides economic and quantitative policy analysis services to all project components and partner organizations. Working with BAPPENAS and its provincial government counterparts, NRM Policy and Planning Group works in three main subject areas: spatial and land use planning; environmental economic valuation; economic analysis/impact assessment. In addition, policy issues related to community-based resource management and land use issues are supported in collaboration with the Forestry Management Group.

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## I. Objective and Approach

This rapid assessment was limited to the geographic area of Dimembe District in Sulut where mercury is used, introduced to the environment and impacts human health, social and institutional activities. This effort was to be completed within a total of three weeks in a two-month period (December 2001 –January 2002). Its objectives were to:

- Present the “big picture”
  - Who is doing what (i.e – identifying stakeholders)?
  - What are the roles, responsibilities, jurisdiction, etc ... of the stakeholders?
  - What are economic, legal, institutional, technical, health, social issues involved with the use of mercury in SSGM.
- Develop and evaluate options for possible *interventions* (defined as an activity that can be funded) that can be supported by NRM/EPIQ, its partners, and other donor agencies in the pursuit of reducing risks and environmental damage associated with the use of mercury in SSGM in the geographic areas mentioned above.

The team developed a list of all the stakeholders that are involved either directly or indirectly with Hg from Small Scale Gold Mining (SSGM). The stakeholders were grouped into Categories. For example, Category I are National Level Government Agencies, Category II stakeholders primarily involved in legal matters; Category III comprise the SSGM community, etc. (see Figure 1 below).

Questionnaires were developed to serve as interview tools. They were:

- Tailored to the specific Categories mentioned to:
  - Ensure relevance of questions asked
  - Serve as reminders so that the significant and important questions pertinent to the category are asked and none forgotten.
- Used to assign “primary” and “support roles” for the team members.



**Figure 1 – Stakeholder List**

Categories	No	Stakeholders
Category I (Critical)	1	Department of Mines and Energy
	2	BAPEDAL (Environmental Management Agency)
Category II (Legal)	1	BPN - Badan Petanahan Nasional (Land Ownership)
	2	Biro Hukum (Bureau of Law)
	3	Hukum Tua (Village Chief)
	4	Notaris (Notary Publics)
Category III (SSGM)	1	Hg Seller/Source
	2	Land Owners
	3	Tromol Owners
	4	Workers (SSGM)
	5	Gold Traders (buyers/sellers)
	6	Tailing Traders (buyers/sellers)
	7	Equipment dealers
Category IV (National Agencies)	1	Ministry of Finance
	2	Department of Defense (Elly asdi)
	3	Perikanan dan Kelautan (Fisheries and Marine)
Category V (Provincial Agencies)	1	- POLDA (Provincial Police)
	2	- POLRES (City/Kabupaten Police)
	3	- KOREM (Army - Provincial)
	4	- KORAMIL (Army - Kecamatan)
	5	Bappeda (Regional Development Planning)
	6	PEMERINTAH DAERAH (Provincial Government)\
		- Gubernur (Governor)
		- Bupati (Mayor)
		- Dispenda (Revenue Office )
		- Dinas Ketertiban (Discipline)
	7	DPRD
	8	Badan Perwakilan Desa (BPD) (Village Representative Board)
Category VI (Private Industry)	1	Indonesian Mining Association
	2	Aurora Gold
Category VII (Donors)	1	GTZ/ProLH
	2	JICA
	3	CEPI
	4	Pusarpedal (Bapedal Laboratory)
Category VIII (NGOs)	1	YBCA (Limbong)
	2	Suara Perempuan
	3	WALHI (Wahana Lingkungan Hidup)
	4	JATAM (Jaringan Advokasi Tambang)
	5	Yayasan Karya Muda Pembaharu
Category IX (SSGM Community)	1	Community
		- Residents
		- merchants
		- farmers
		- tambaks (fresh/estuarine waters)
		- Ojeks
		- Security service
		- University
Category X (Health Agencies)		- Entrepreneur (setting up tailings treatment using cyanide)
Category XI (Media)	1	Kesehatan (Health)
	2	Kesehatan Tenaga Kerja (OSHA)
Category XI (Media)	1	Media
		- Radio
		- TV
		- Newspaper/Print

## II. Observations, Findings, Notes

In this section is presented the brief summary, after synthesis, of the results of all the interviews. They touch upon the following topics and issues:

- Legal (Regulatory, Property Rights, ... )
- Labor and Social
- Technical
- Environmental and Health Impacts
- Economics
- Other Important Issues

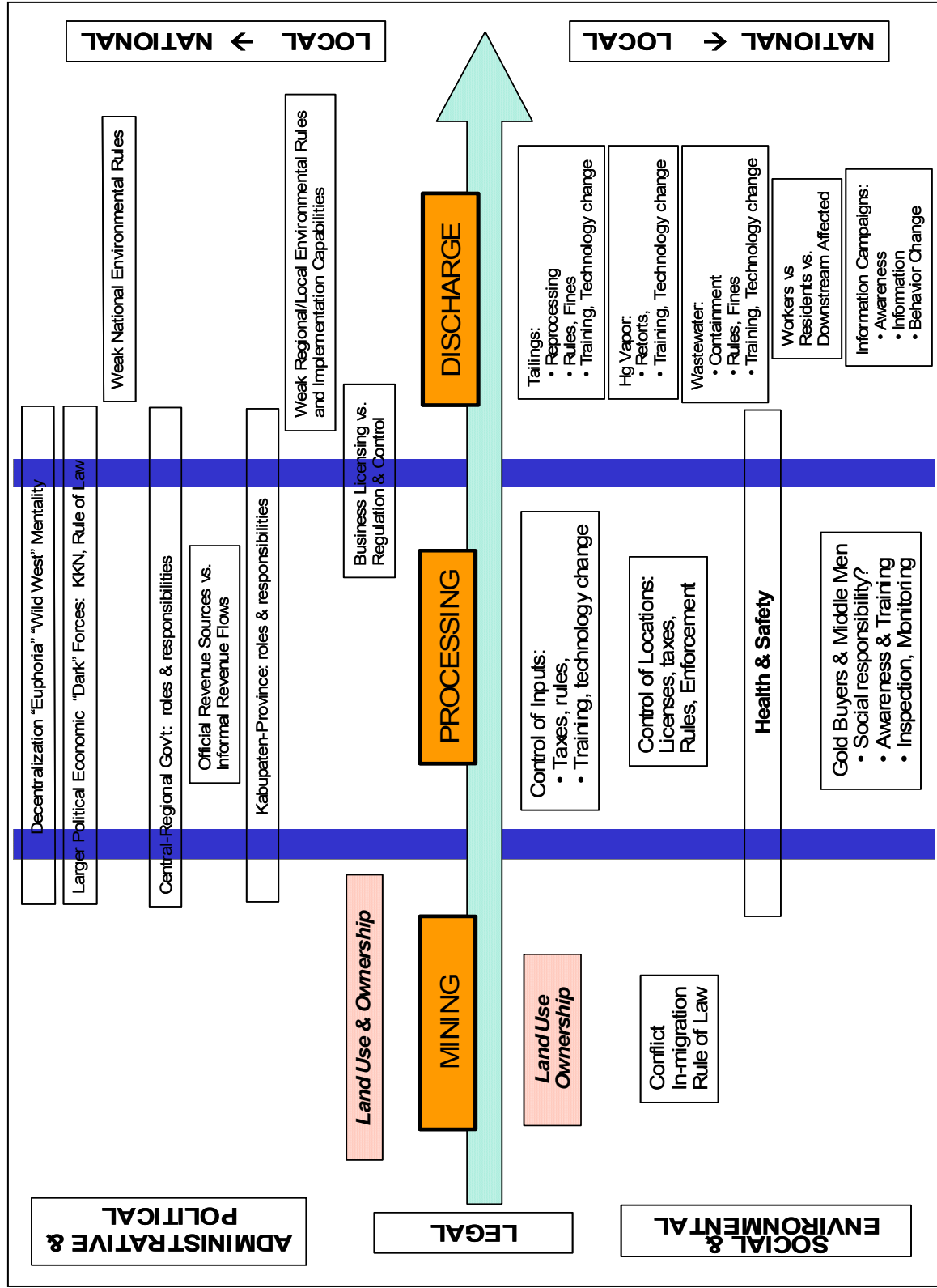
Figure 2 presents a map of the key issues which are described below

### 2.1 Legal and Property Right Issues

The assessment team found that issues related to property rights, i.e. access to and control over the land and mineral resources appeared to be the key issue in the current problems and potential solutions for SSGM and mercury related problems in the Dimembe District. Small scale gold mining and processing operations are being held within the land area that belong to Tanah Passini. These lands bear customary ownership and use rights under the local traditional/*adat* law. As of the end of 2001, about 80% of the mining and processing facilities in Talawaan and Tatelu (areas where these activities are mostly concentrated in Dimembe District) were owned by the people of local origin. This ownership pattern is a reversal of the situation when the activities started in 1998. At the early stage, small scale mining and processing entrepreneurs/operators came mostly from Kabupaten Bolaang Mangondow/Kotamobagu area. As capital and knowledge accumulated in the Dimembe area, the ownership shifted toward the locals. Local researchers, community leaders and provincial government have confirmed this shift of ownership pattern.

The central government agencies labeled the SSGM activities in Dimembe District as PETI (*Penambangan Tanpa Ijin* – i.e. gold mining without permit), more popularly known as illegal mining practices. The central agencies, including the Ministry of Mines and Mineral Resources and *Tim Pusat Penanggulangan dan Penertiban PETI* (TP3 PETI - i.e. Integrated Central Team To Deal with Illegal Gold Mining Without Permit), define small scale illegal mining activities as those operating without permit prescribed by article 11(2) Law 11/1967, i.e. the Basic Mining Law.

**Figure 2 - Hg IN SSGM: MAP OF KEY ISSUES**



In the context of SSGM issues, the Law claims five crucial things:

- that the state owns an exclusive mineral right over all mineral resources within Indonesian territory;
- that the central government c.q. Minister of Mines and Mineral Resources allocates the right to implement the mining operation through Kuasa Pertambangan (Mining Privilege) and Contract of Work (CoW) mechanisms to business entity;
- that the small scale mining operation for mineral under category 'a' – gold belongs to this – will only be allowed under Pertambangan Rakyat (small scale community mining) if the amount of the deposit is so small that it is more profitable to be exploited using simple technology and at small scale;
- land owners, despite its ownership right upon the parcel, are required to surrender their access and control over the land to the CoW holder; and
- holder of Mining Privilege/CoW is required to compensate the land owner for the loss of the use right over the land and everything valuable at the surface.

In the mid-nineties, the central government awarded CoWs to two companies, PT. Mearess Soputan Mining (MSM) and PT. Tambang Tondano Nusajaya (TTN) to operate gold mining and processing facilities in North Sulawesi. Both companies are joint ventures between PT. Austindo – an Indonesian company group, and Aurora Gold, an Australian company, as the main shareholder. The CoWs area include all locations in Dimembe District that are currently being used by the community to mine and process gold ores. In fact, a significant upsurge of the SSGM in Talawaan – Tatelu only happened after a series of exploration works by TTN/Aurora.<sup>1</sup> At the peak of the country's multi-dimensional crises in 1998, after acquiring some small parcels of lands for exploratory works, Aurora left the site in concurrent time with the influx of small scale miners. The wave of decentralization euphoria has also made its impact on SSGM activities in the Dimembe district. Chaotic licensing and permitting mechanisms and the associated frontier area syndrome appeared during the early stage of SSGM activity. Later on, community leaders and local authorities at the village and *kecamatan* level developed local regulations and rules of conduct for the parties involved in SSGM. This was primarily to maintain order at the local level.

The conflict of interests emerged when Aurora/Austindo wanted to get back to business. The company insisted to have the exclusive right over the Talawaan-Tatelu area since the exploration work shows that it is the richest part of their CoW area which will guarantee the profitability of its investment. The central government, through TP3 PETI wants the SSGM activities to stop

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<sup>1</sup> However, there are traces of information that need to be verified that the knowledge about the existence of the gold in the area is dated back to 1922, involvement of Dutch scientists, and SSGM activities for a short period of time in early 1950s.

and all CoW areas be surrendered to Aurora/Austindo. The company was prepared to compensate communities for the area to be taken over by the company. *Dinas Pertambangan Propinsi* (Provincial Mining Administration) and the government of Kabupaten Minahasa are supporting this proposal. *Kabupaten* government's primary concerns are the revenues from property tax if the area is managed by a formal business entity, plus, as promulgated in law 25/99 on the balance of central-regional fiscal resources, a share of royalty and land rent that the company has to pay to central government. Both *Dinas* and *Kabupaten* governments suggest to move the existing SSGM (including mining and processing) units to a new location to be designated as *Wilayah Pertambangan Rakyat* (WPR – a designated community mining area).

The existing SSGM communities refused to surrender their lands and to move to other WPR areas for obvious reason. The fact that 100% of the land in the area falls within *Tanah Passini* status, and all problems associated with land take over through government power and public consultation in regional development, give the community strong reasons to keep the area. The promulgation of TAP MPR No. IX/2001 (Decree of the General Assembly) on *Agrarian Reform and Natural Resources Management* provides a stronger base for the local indigenous people to defend their property. Among the mandates in the decree is that the government should ensure justice, fairness and recognition of customary right through restructuring of ownership, access, control upon and utilization of agrarian and natural resources. TAP MPR IX/2001 will become the basis of new and revisions of old laws dealing with natural resources.

The provincial government, recognizing: (1) that forcing the implementation of existing CoW will escalate conflict, and (2) that no aspects (especially pollution) of 'illegal' business practice can be regulated, have come up with a quid-pro-quo approach. Series of dialogues have been undertaken with the SSGM communities that resulted in an 'informal' agreement in September 2000. It has four components:

- A proposal to central government to ask TTN/Aurora to relinquish the existing SSGM locations from its CoW, and turn the location into an officially designated WPR.
- The SSGM owners (of mining and processing units) are to adhere to certain set of rules and standards for better mining practice and environmental management.
- The small scale processors are to move to localized zones.
- The small scale processors are to stop using mercury and shift toward cyanide-based technology with an agreed-upon deadline.

While TP3 PETI denounces the proposal to change the existing SSGM location into WPR, the provincial government claims that the Minister of Mines and Energy had stated that he will agree

if TTN/Aurora Gold agree to relinquish the area. The latest situation on the legality and property right status is that activities of SSGM continue. The provincial government is endorsing the establishment of a small scale cyanide-based gold processing unit in the Kolongan village (presently designed to only process “tailings” from existing SSGM), to promote best practices. The unit can be added to or modified to handle the ore itself, if future conditions warrant.

As of the end of 2001, Aurora Gold had decided to sell its shares in TTN and MSM and ready to write off a USD 30 million loss from its early investment.

## **2.2 Labor and Social Issues**

- Gender
- Sources of labor
- Compensation
- Labor Relation
- Social Problems

### **2.2.1 Gender**

In general there are three groups of worker:

- Mine workers, all men working as a team of 10 – 15 people. They work in shifts so the mine activity can run continuously. They left their families back home and live in shelters built above the mining pits. Laborers are fed and paid a minimal wage to support their families during startup. Once the mined ore produces gold after processing, they usually share in the gold production.
- Manual crushing is done by men and women. There are differences in their wages, a man receives Rp. 60,000/day and a woman Rp. 30,000/day. According to them this is because of the differences in working hours, a woman works less hours. Women come later in the day because they have to do domestic work first. There are no fee differences for “package” work between men and women, because it is based on output which is Rp. 25,000 – Rp. 45,000 / bag of 50 kg.
- Trommel operators and smelting process employees are mostly men. Trommel employees’ wages are Rp. 400,000/month plus food and lodging.
- Women are involved at all levels in SSGM and processing, but not in substantial numbers. It is not uncommon to see 6 – 8 woman crushing ore at a processing plant. Small children are often present, as the mothers must still attend to their younger children. Several women are also owners and/or managing operators, in which capacity they spend considerable time of

each day at the plant. In one of the sites observed, the “Kepala Desa” is a woman who owns a processing plant as well.

- While the women are not directly involved in the “roasting” of amalgam, they and their children who happen to be present are exposed daily to the toxic fumes. Most women do not have any idea about the danger of mercury vapors.
- Children come along with parents who work in the mining and processing plant. They might spend considerable time of each day at the plant. Occasionally children are used for crushing ore. They play near their parents who work under a canopy that is usually connected with the main processing area, or at least near the area where amalgams are roasted.

### **2.2.2 Source(s) of Labor**

- Approximately 75% of the laborers come from outside the community, from Sulawesi.
- Mine workers come from Kotamobagu, Langowan, Ratatotok and Sangir (a stretch of islands in the north-eastern part of North Sulawesi province). They are “professional mine workers”, move around mining locations. They work as a team of 10 – 15 people recruited by sponsors who give them working capital. When the mine starts producing ore they start sharing the yield.
- Trommel operators (Do not have enough information)
- Crushers come from Langowan, Paso Kabupaten Minahasa. Those who crush ore manually come in groups of families (husband and wives). Previously, they were daily agricultural laborers.

### **2.2.3 Compensation**

- Most miners worked either as miners or as farmers prior to taking up employment at the mining pit.
- Most laborers employed at the processing plants worked as farmers prior to taking up employment at the processing plant.
- In general, wages in mining and processing plant are higher than daily income in agriculture. Workers switch jobs because crushing wages, for example, are 4 times as much. Seasons do impact the labor picture. During last year’s clove harvesting seasons, there were less mining workers available. Clove harvesting is still relatively promising compared to mining. Especially because the risk is lower and cloves nowadays sell at a good price in the market.

### **2.2.4 Labor Relations Issues**

- Incoming laborers versus those from the Local Community

- Investment shift: More and more Tatelu residents become processing unit owners. They learned the technology while their land was rented by outside investors, and after that they started their own processing plant after they have enough money and experience. In the study area, some local residents own 100% of the processing plants.
- There are other issues such as political conflicts, hierarchal status of workers/groups and workers from the area (local) versus those from outside the area (Incoming) – but there is not enough information at this time to discuss them.

### **2.2.5 Social Issues**

- Although anecdotal stories indicate that crime rates were increasing because of SSGM activity, there are no recorded data on this increase. There are times when mine workers kill each other for rights to a mining pit, but that is limited to only the vicinity around mining locations. Local communities blame the transient laborers as the main source of increase in crimes.
- The crime rate around SSGM areas is changing. Previously, there were many incoming thugs which increases the incidence of crime around mining location and spread to the surrounding area. People could not pass by that area at night (because the thugs would stop the car and ask for money). Because of the shift occurring in ownership, there is a revival of law and order so the incidence of crime is decreasing.
- Processing unit owners give the local government money for security. The amount of fee and its mechanism were discussed and agreed among local government (*desa*), and trommel owners. This gives them a sense of control.
- Gambling is a common activity in the study area. So is “*cap tikus*” drinking. This is a common activity of the mining workers. According to them *cap tikus* (local wine) could prevent them from cold.

## **2.3 Technical**

Any of the three viable gold extraction technological/processes which can be used in SSGM is well developed and known. There might be some “fine tuning” for the “specific application” issues that need to be considered (example: scaling up or down known operational and economic information from past and present operation of established larger mining companies). No new basic knowledge and information needs to be developed. The technologies and processes are straight-forward. Scaling up or down from existing cyanide based operations is not an issue nor an impediment. It can be done to the level of existing individual small scale operators or to a larger scale such as might be formed as “Cooperatives” or “Association”. See also section 2.5.3.



If the cyanide process is to be used in SSGM, however, it would be necessary to provide training to operators on the handling of raw materials (its storage, transport, use, etc...) and on safe plant operating procedures.

What is relevant to this assessment is what and how technology/process knowledge needs to be communicated and shared with the stakeholders:

- Large mining companies such as Newmont Minahasa Raya in Ratatotok and PT. Aneka Tambang in Pongkor, West Java are using the closed-loop cyanidation technique for gold processing.
- The level of knowledge and understanding of the various stakeholders about the technologies and process vary considerably. It would be necessary, as a first step, for the knowledge and information to be presented to all the stakeholders (individually or small groups initially – a workshop involving all, eventually). Without this first step, facilitating group discussion and workshops about the technical aspects of the mercury-related issues will be, at best, difficult – probably, impossible.
- Most stakeholders did not even know that a cyanide based gold extraction process (for tailings) is under construction in the study area. The unit under construction was established with the intention to reprocess (mercury-contaminated) tailing purchased from operating trommel in the neighboring villages of Tatelu, Talawaan and others. The provincial government and/or the entrepreneur have not done a good job (maybe that is not a goal of theirs) of informing the stakeholders. Mining operators and processor kept asking for a pilot demonstration (technical aspects) and economic information.
- This cyanide based tailings treatment plant under construction is not a closed loop system. There will be the possibility of cyanide discharge (over flow and ground seepage) from the plant's tailing pond. The tailing (containing cyanide compounds) will be channeled to a tailing pond where the compound will biodegrade into non-active forms of cyanide. The oxidation process for “breaking down” the cyanide can be expedited. Use of chlorination, peroxide, even plain aeration can be employed. However, there will be a capital investment cost for any option chosen.
- Technical aspects of mining and ore processing need to be communicated.
  - ***From the mining aspect***, information about kinds of ore, differences between them, technology/process that is best suited for use if highest gold extraction efficiency is the goal, etc... needs to be presented.
  - ***From the ore processing standpoint***, the mercury Amalgamation and the Cyanidation processes are the only two processes that are significant and applicable to the study area. A third “hybrid” process which involves use of both mercury (from crushing to gold

extraction at retort) and cyanide (for gold extraction and mercury recovery for tailings) could be classified as a third option but it still deals with mercury and cyanide technologies, basically. NRM/EPIQ and USAID experts and consultant(s) on technology and process would be needed to facilitate knowledge transfer and “awareness raising”. This should be a potential intervention which should be given serious consideration if progress is to be made in mitigating the mercury-related concerns from SSGM.

## **2.4 Environmental and Health Impacts**

The main environmental issues arising from the current SSGM’s operation in Talawaan include mercury contamination from the gold processing, river siltations from improper tailing management and landscape alteration from excavation and/or abandoned mining pits. Currently none of the SSGM operation’s in SULUT is using anything other than mercury-based gold processing technique. However, the team discovered a cyanide-based tailing reprocessing plant under construction in Kolongan village.

### **2.4.1 Environmental and Health Impacts of mercury**

At the study location, the trommel workers are potentially exposed to mercury by skin absorption, from inhalation and ingestion of contaminated food and water. The exposures occur throughout ore processing.

- Mercury is added to the ball mills in which the ore is crushed. Following several hours of milling, the resulting amalgam is collected by bare hands and placed in a cloth where the remaining liquid is separated. These manual chores are conducted without gloves, exposing the workers to mercury through skin absorption. The resulting soft round amalgam is torched in the open air to vaporize mercury. Without any protective gears, the workers inhale mercuric vapor.
- A handful of trommel owners have purchased the retort (sold by Yayasan Bina Cipta Aquatech (YBCA), a local NGO), an equipment which captures mercuric vapor and recycles the condensed mercury. Its use protects the workers from inhalation exposure. However, the majority of trommel owners do not use the retort although they have been informed about the benefits.
- Most processing units do not have adequate tailing ponds. The mercury-contaminated tailing is discharged directly to the stream that feeds into the major river. The local residents and workers use the same river as source for drinking and cooking water. Some commercial

fishponds also use the same water source. The potential exposure to miners and residents from ingestion of contaminated food and water is very likely.

- The SSGM's community has been informed about the potential environmental and health impacts of mercury exposures. YBCA has conducted educational campaign activities targeting the miners. Posters and pamphlets (distributed by YBCA) regarding the danger and threat were seen at the huts of some processing units. However, the larger community (in the city of Manado or other districts) are not aware of the threat.
- It has been reported that some workers have complained of muscle weakness, blurred vision and hand tremors. All are early signs of mercury poisoning. There was no official health records regarding people suffering from mercury toxicity. Most workers did not seek medical assistance when they suffered illness. Some would not admit they have come down with the symptoms. And even if they seek relief or medical interventions, the local PUSKESMAS doctors would not been able to properly diagnose and treat the symptoms. The miners have adopted a cavalier attitude. They continue to risk their health because of the attractive wages.
- YBCA has also conducted several monitoring programs in year 2000 and 2001 to survey the environmental and human health impact in Talawaan watershed. Samples from environmental media (water, soil, snail, fish) and human urine were tested for mercury contamination. Mercury was discovered in the water and sediments from three major rivers (Talawaan, Kima and Bailang rivers). Analytical data obtained in year 2001 from several locations in Talawaan River show mercury levels (0,002 to 0,006 mg/L) that are generally above Indonesian's water quality standard for drinking water (0,001 mg/L). Sediments from the same river also show elevated levels of mercury 0,06 to 10,7 mg/kg (EU/OECD standard is 2 mg/kg).
- Human urine data were obtained from 63 individuals consisting of processing plant workers, miners and nearby residents. Concentrations were highest in the processing plant worker group (202.65 µg/L), followed by miners (182.64 µg/L) and nearby residents (34.55 µg/L). Maximum safe level of occupational exposure is 50 µg/L. Unfortunately there are no clinical observations for the above individuals to correlate the high urine level with clinical signs of mercury poisoning.

#### **2.4.2 Environmental and Health Impact of Cyanide**

- Unlike mercury, cyanide is a toxic substance that will have an immediate impact but will biodegrade once released into the environment. Cyanidation is an agent of choice for gold processing. This is due to the combination of its availability, effectiveness, relatively

favorable economics, a proven level of technology and an overall ability to use it with acceptable risk to humans and the environment. It binds with the gold and leaches the gold from the ore. Cyanide is highly toxic to fish and mammals at low doses. The toxicity depends on the form.

- People may be exposed to cyanide through inhalation, ingestion of contaminated food and water and by skin absorption. Once it enters the body, cyanide can quickly get into the bloodstream. Exposure to large amounts of cyanide can be deadly. The severity of the harmful effects depends in part on the form of cyanide.
- The health effects of large amounts of cyanide are similar, whether it is eaten, drunk, breathed, or touched. Skin contact with hydrogen cyanide or cyanide salts can irritate and produce sores. Workers who breathed in amounts of hydrogen cyanide as low as 6 to 10 ppm over a period of years had breathing difficulties, pain in the heart area, vomiting, blood changes, headaches, and enlargement of the thyroid gland.
- Based on available information, the most likely exposure pathways are from ingestion of cyanide compounds and by skin absorption.

#### **2.4.3 Occupational Safety and Health**

- Most transient laborers are living temporarily for short periods of time at the nearby community, at the locations of mining shaft or at the processing unit. Health and sanitation conditions are generally very poor. They are forced to use contaminated water as sources of drinking water and for cooking. Often, the trommels operate 24 hours a day, all year round. Their homes are their place of work and they live in the midst of mining activities that never cease.
- Some anecdotal information regarding casualties related to extraction and processing steps were recorded in the interviews with the miners.
  - A few underground miners were found dead inside “caved-in” tunnels or from lack of ventilation.
  - An accident involved a trommel operator whose shirt got caught in the conveyor belt. He was fatally injured. Official records were not available to verify.
- Personal safety and protective equipment is not available. All miners go underground wearing nothing but short pants (without hard hats or boots). Trommel operators are only wearing short pants also to avoid the risks of getting their personal clothing tangled in the movement of conveyor belts.
- The miner mainly relies on whatever resources they have for emergency or first aid. They visit the local PUSKESMAS for health care and first aid treatment. Since these laborers are

mostly non-local, they usually return to their respective homes when they are sick, suffer injury or are unable to carry on the work. As a consequence, it is difficult to obtain accurate health records from SSGM's community.

- The use of the cyanide process will require extensive training of all involved in SSGM activities in the areas of (1) materials handling, and (2) plant and operational safety operations. The dangers from exposure to cyanide in its lethal form will need to be shared with the owners, operators, and the community. Cyanide will kill quickly, unlike Hg whose health impacts do not show up for a long time after exposure to it

## 2.5 Economics Dimension of Mercury Issues in SSGM in Talawaan Watershed

### 2.5.1 Macro Dimension

The following statistics reveal an estimated overall situation in the whole Dimembe District with respect to SSGM related economic issues at the end of 2001. This is based on previous studies and recent observations by local researchers.

Number of active mine shafts	300 units
Number of active processing mills (mercury-based)	400 units
Number of active gold buyers	60 persons
Number of mine workers involved	4,000 – 6,500 persons
- mining	2,000 – 2,500
- trommel/processing	2,000 – 3,000
- ore transporter (horse/cow carts, jeep)	250
- manual ore crusher	600
- <i>ojek</i> (motorcycle local ride service)	200
- security and others	100

In terms of output and values, the current level of SSGM activities in the Dimembe district, with high concentration in Talawaan – Tatelu area, provides us with the general estimates as shown below:

Amount of gold produced

- (estimated based on daily gold trade) = 9,000 gram/day = 2,700 kgs/year.

Value of gold bullion sold at producer's gate

- (@ Rp.60,000/gram) = Rp. 540 Mill./day = Rp. 162 Bill./yr

#### Potential revenues from royalty if legal

- @1% as apply to other gold mines	Rp. 1.62 Bill./yr
- Share of Kabupaten Minahasa (32%)	Rp. 518 Mill./yr
- Share of North Sulawesi Province (16%)	Rp. 259 Mill./yr

For comparison, *under the scenario of TTN and MSM from all its CoW area ( not just Dimembe district)*, based on data provided by Aurora officials, we can estimate the following:

- Production/year for the first 6 years = 180,000 ounces =	5,103 kg/year
- Total value @Rp. 60,000/gr =	Rp. 308.2 Bill./yr
- Potential royalty @ 1%	Rp. 3.1 Bill./yr
- Share of Kabupaten Minahasa (32%)	Rp. 992 Mill./yr
- Share of North Sulawesi Province (16%)	Rp. 512 Mill./yr

Comparison between the current situation at Dimembe district (a small part of Aurora's total CoW area) and the Aurora scenario reveals that Dimembe district could potentially contribute at least half of the total value of the joint results of the CoW. This confirms that Dimembe district has the prime value to Aurora's investment. However, the figures also raise an interesting question whether the claim of inefficiency of the SSGM activities is a real or false issue.

#### **2.5.2 Micro Dimension**

There are several groups of people who directly and indirectly benefit in different ways.

##### **Directly**

- land owners of which there are two categories:
  - those who lease the land for mining activities (either the mine shaft or trommel processing location. The price for land rental for approximately 36 square meters is 150,000 rupiah per month.
  - those who own the land and are involved directly in the mining activity and processing. This type of land owner gets a 30% share of the miner's reap.
- owners/investors who have capital to back up all the mining activities. Their share of the benefits are not known.
- trommel owners who benefit the most from SSGM activities since they get the highest value added. This group can be sub-categorized as:
  - the trommel owners who also have a mine shaft.

- those who buy the gold ores from others. In some cases, the owners also get benefits from selling the tailings to another party for re-processing. Their average revenues are estimated to be *Rp. 18 million* per month.
- crushing machine owners (crushers usually are also owned by trommel owners). Besides processing their own ores, they also rent the machine to others. The fee for crushing the ores is 15,000 rupiah per 50 kg bag of ore. Their average income is between 225-450,000 rupiah per month.
- Miners who are in the front line of SSGM. They do not get sufficient benefits as assumed. On average, their wage is 400,000 rupiah per month plus meals, extras (cigarettes and coffee), and simple lodging provisions.
- Crushing machines workers, some of whom are paid on a monthly basis and some on a daily basis. Those who get paid monthly on average are paid the same as those that work in the mining shaft. The ones that are paid daily earn in the range of 30-60,000 Rupiahs per day depending on gender and experience.
- Processors (same as above).
- gold buyers: this group of about 30 individuals come to the site on an occasional basis. There is no estimate of profit they make. On average, they purchase about 100-200 grams of gold per day. The price of gold on site is around 60,000 rupiah per gram depending on its quality.

### **Indirectly**

- trommel manufacturers and workshops: There are several trommel manufacturers and workshops on site. They provide new trommels for sale as well as provide repair services for broken trommels and processing machineries;
- transporters:
  - those who have pick-up vehicles and cow-pulled carts. Cart owners earn 200,000 rupiahs per day for transporting approximately 20 bags of ore from mining site to processing site.
  - Those who provide people transport services (*ojek* and *angkot*). There are about 200 *ojeks* in the area with the average income between 40-50,000 rupiah per day.
- Those who provide security: the informal group of ‘thugs’ acknowledged by *Desa* who charge the shaft and trommel owners 100,000 rupiah per week plus bonus on the big yield
- Those who sell supplies and provide catering service (*warung*): This group benefits by selling supplies and foods to the miners and workers. In one SSGM location in Tatelu, a *warung* owner reported sales of about Rp. 5 million per week. The workers get their meals

and daily necessity from the *warung* in repeated cycles: buy on credit, pay off debt when the salary (or income from gold share) comes, and fall into debt again.

### 2.5.3 Economic Issues Related to Technological Options

As has been discussed in earlier reports, it seems that there is an opportunity to encourage a shift in the technology used by the SSGM community from mercury amalgamation process to cyanide-based processing. Two focus group discussions conducted during the assessment week revealed that SSGM communities in Talawaan and Tatelu area are receptive to the idea of shifting toward cyanidation method. They have heard that the ‘new’ cyanidation method is more environmentally friendly despite requiring larger scale of operation and higher technical training for the workers. The trommel owners expressed interest in learning more and expecting to have the opportunity to actually learn from a pilot cyanide-based plant.

From the economics point of view, there are four major issues related to a shift to cyanide-based processing technology. They are:

- ***relative profitability*** of the technology if applied for the same gold deposits and ore types;
- ***replicability of cyanide-based technology at smaller scale*** of operation;
- development of ***producers’ cooperative*** and rules of benefit sharing if a merger of small-scale processors is a prerequisite, to achieve the minimum economies of scale.
- ***Relative costs of externalities*** associated with the choice of new technology compared to simpler mercury-based plant; and

#### **Relative profitability**

To encourage the shift toward cyanidation technology, it is essential to show that it is a more profitable option relative to the existing mercury amalgamation process. Based on available information, the following preliminary “estimates of profitability” feature and comparison are given for a typical mercury-based processing unit and an expected calculation from a cyanide-based plant still under construction in the village of Kolongan, Dimembe District. If a significant additional capital investment is needed or desired to make the operation adequately environmentally friendly, the economic picture no doubt will change. A more detailed financial calculation will be needed to acquire a better understanding of the situation, if this case arises.

The typical mercury-based ore-processing unit used in this calculation has 12 trommels that run three shifts per day for 25 workdays. The second and third shifts reprocess tailings from the first



milling. The owner invested Rp. 45 million rupiah at the beginning and employs 4 manual workers. The Table #1 displays the basic summary of the profitability feature of this operation.

The figures for cyanide-based technology refer to a 10-ton size main processing unit being constructed. The facility is estimated to run at 6 days/cycle and 6 cycles per month. The owner invests Rp. 300 million with the expectation that by reprocessing the tailings of the neighboring mercury-based operation. He could extract about 30 grams of gold per ton. The number is based on a series of assays that he had made. The remaining gold in the tailings of mercury-based operation are due to low recovery efficiency of the mercury-based technology. In general people believe that the gold capture rate of the mercury-based operation is less than 40% as compared to 90% of the cyanide-based facility. The difference in the gold capture alone may justify a shift from mercury to cyanide-based technology.

**Table 1: Typical Example from a Mercury-based Operation**

A. Estimated gold production per month	288.0	grams
<b>B. Value of monthly gold production</b>	<b>17,280,000</b>	<b>Rp</b>
C. Cost of input: (virgin ore per bag)	80,000	Rp
- price of virgin ore per bag Rp. 50,000		
- transport per bag Rp. 15,000		
- crushing per bag Rp. 15,000		
<i>Total input cost per month for 100 bags of virgin ore</i>	<i>8,000,000.0</i>	<i>Rp</i>
D. Operational Costs per Month:		
- Labor costs (4 person x Rp.800,000/m incl. S+f+l)	3,200,000.0	
- Fuel (25 litre diesel/day @ Rp. 1000) for 28 days	700,000.0	
-Trommel drum replacement cost (every 6 month)	1,500,000.0	
- Land rent	500,000.0	
- Capital depreciation costs (Rp. 45 m investment for 8 yr duration)	468,750.0	
- Security cost	100,000.0	
- Mercury for amalgamation ***)	62,500.0	
<i>Total operational costs per month</i>	<i>6,531,250.0</i>	
<b>E. Total cost/month (C+D)</b>	<b>14,531,250.0</b>	
<b>F. Estimated net profit for processors owner</b>	<b>2,748,750</b>	
<b>- Rate of return (F/E)</b>	<b>19%</b>	
***) (IF the amount of mercury loss per drum per shift is 55 grams as reported by URS, then it won't be a profitable business. The total mercury cost to processor per month will be Rp. 7,425,000 @ Rp.150,000/kg). The calculation would be $0.055 \times 12 \times 3 \times 25 \times \text{Rp.}150,000/\text{kg} = 7,425,000$		

**Table 2: Profitability of Cyanide-based Technology (Kolongan case)**

A. Gold Production/cycle (30 gr/ton input)	300.0	gr
- production per month (= 6 cycles @ 5 days each)	1,800.0	
B. Value of monthly production @Rp. 60,000	108,000,000.0	Rp
C. Input for cycle		
- ore or tailings of mercury-based process @10000kg/cycle	60,000.0	kg
- sodium cyanide (12 kg/cycle)	72.0	
- active carbon (@10 kg/load) reusable	10.0	
- fuel (diesel) (100/day)	3,000.0	litre
D. Price of input		
- ore/tailings	50,000.0	
- sodium cyanide	16,000.0	
- active carbon	3,600,000.0	
- fuel	1,000.0	
E. Input cost (C*D)	77,652,000.0	
F. Depreciation cost (Rp. 300 million for 8 years)**)	3,125,000.0	
G. Land rent	1,000,000.0	
H. Security	250,000.0	
I. Total cost/month	82,027,000.0	
J. Estimated net profit	25,973,000.0	
K. - Rate of return (J/I)	32%	

\*\*) Rp. 300 million include Rp. 150 million price of the assaying laboratory, and the same amount invested for machineries, building and tailing ponds. An additional capital investment to what is shown might be necessary for a more environmentally friendly operation (for example, "lining" the pond to prevent seepage).

The comparison between these two technologies, as shown in Table 1 and Table 2, suggests that the cyanide-based operation provides the processor owner a much higher rate of return. However, the total initial capital investment may hinder the investment in this technology. That is why replicability of cyanide based technology at smaller scale is highly relevant to ensure profitability for the SME operating in this business.

### **Replicability of Cyanide-based technology at smaller scale**

There are two scenarios possible for scaling down the existing Kolongan cyanide-based operation. Both are possible and viable, technically. One scenario is to operate at the existing level of individual small scale operators and the other scenarios is at a “larger- than-individual-small-scale” of operation, if the formation of “Cooperatives or Associations” is decided upon.

In the first case, the size of the vat for mixing the cyanide compound with other materials could be as small as a 55 gallon drum.

In the second case, gold content in the ores as well as the issue of using additional equipment become relevant. The use of ore concentrator prior to the pulp agitation unit (main processing tank) could increase efficiency due to having a higher gold concentrate. The ore owner can choose to process only ores with (presumably) high gold content which has been separated from the waste rocks by the concentrator unit. Experience in the Philippines and South America suggests that the main processing tank with the minimum size of 300 kg ore is a viable business. The entrepreneur and the technician in Kolongan estimated that the break-even level of gold concentration in the ore will be about 20 grams/ton ore for that size of processor. The use of a concentrator will certainly increase productivity in this smaller scale operation. The 300 kg minimum scale for cyanide-based processing unit coincides with the capacity of the existing 10 trommel drum mercury-based processing facilities in the Dimembe area. Presumably, existing processors with this capacity or larger could easily shift toward the cyanide-based technology. The size of the main processing tank can be customized between 300 kg and 10 ton to ensure profitability, together with the appropriate choice of size of other equipment such as power generator, etc.

The assaying laboratory that is being built in Kolongan can be used by all the members of SSGM communities in the Dimembe District area who wants to know the gold content of their ores. In the Philippines, the assaying laboratories charge their customer 300 pesos per test (around Rp. 60,000) for the analysis of gold, silver and copper content of the ore.

The existence of cyanide-based operation that promises higher gold recovery rate also opens the possibility to develop *custom milling (processing) service* for anyone in the area who wants to process their ores.

### **Producer cooperatives and benefit sharing arrangement to facilitate merger**

If the use of cyanide-based process at small scale individual miner level is not allowed, a critical issue for profitability is facilitation of developing a business “association” (something like producers cooperative) for raising scale of operation and sharing capital. Related to it is the development of rules of association (such as benefit sharing arrangement, treatment of ore from different sources with different gold content, transparency of process and output collection during the mechanical process, etc.).

### **Relative costs of externalities**

Despite significant economic benefits that can be realized by a few stakeholder groups, there are also costs to the overall economy caused by SSGM activities. Those who bear the costs (capital invested and operational cost) from SSGM, to some extent, include the groups that are benefited and others who get the externalities. The main externality of mercury-based processing activities will be the costs to the overall economy from the leakage of mercury from the milling process, from the de-amalgamation process, as well from the tailings. At this point there is no valuation study to estimate the potential externality costs to the local and regional economy. However, if the use of mercury continues as it is being used now, economic losses are expected to materialize.

- Income loss due to health impairment or increase in the costs of maintaining health associated with exposure to mercury contamination. Workers in the processing areas, especially those who directly handle mercury, are the ones with the highest risk.
- Communities surrounding processing plants, through several exposure paths, will experience the same.
- Fresh water fish and agriculture crop production may be affected through leaching of mercury in the soil and through water bodies. At present, consumers start to discriminate against products that come from Dimembe because of the image that the fish are contaminated with mercury and dangerous to be consumed.
- Eventually, the image of mercury contamination may reach the stage where everything which comes from or is located in North Sulawesi is labeled ‘mercury polluted’. It may hurt tourism and fishery exports from the province.

From the above list of potential externality costs, cyanide-based processing technology will be more appealing because the cyanide compound, despite its toxicity character at impact, will not stay in the environment for a long time period. It decays after a couple of days of sunlight exposure. However, it cannot be over-emphasized that the use of cyanide needs better handling and proper equipment and training of workers due to its immediate deadly impact. These may affect some increase in cost calculation. Nevertheless, to save the workers life at the work place, to conserve the quality of the environment, to increase efficiency in resource use, and to increase the rate of investment return, shifting toward a cyanide-based technology seems to be a logical step to take.

## **2.6 Other Important Issues**

Other significant and important issues identified from the interviews are:

- Communications – General “awareness raising” of the entire community, which deals either directly or indirectly with Hg, is needed. Much information about economics, technology/process, legal, health, social and institutional can be shared for all the various community groups. It is important for the stakeholders to be as informed as possible about the topics of concern to them or for which they have specific roles of responsibilities to carry out.
- Coordination – This is critical among government agencies so as to provide a clear and consistent direction for the regulated community. In a way, this issue ties in with “communication”. It was revealing to learn during the interview that at the Provincial level the shift to the cyanide process is being encouraged while at the *Kabupaten* level the idea of a shift to the cyanide process is not acceptable. Where does this put the regulated community? In limbo and confusion, of course. Some have expressed no surprise. Rather, they just point to it as to why government cannot be taken seriously nor looked to for direction.
- Institutional Development – An “infrastructure” with clear roles and responsibilities to address the Hg issue (policy development, enforcement, outreach ...) is needed. Is the existing infrastructure effective and efficient? A more basic question is: What is the infrastructure? The all important questions about roles and responsibilities are unanswered. What is the relationship between Department of Mines and the Provincial levels of governance for SSGM activities? The unclear picture leads to either an avoidance of responsibility or non-activity because of uncertainty. Facilitating meetings, workshop,

seminars to address this issue is necessary before any kind of mitigation of mercury-related problems for SSGM can be identified.

- Administration/Implementation – The various organizations resulting from the Institutional Infrastructure Development must have specific and clearly defined Roles and Responsibilities to avoid duplicity and confusion (which frequently leads to inaction and “buck-passing”) and which would result in effective and efficient operations. The specific “mechanism and roles” of operation should be documented and distributed to all concerned.
- Legal – Effective regulatory programs must have a clear legal basis which can be identified as the “source” and “basis” of authority. These laws and regulations are especially needed in:
  - Permit Programs for :
    - Permit Issuance
    - Contract of Work (COW)
    - Mineral Rights
  - Compliance Determination Programs some of which involve Inspections.
  - Enforcement Programs which clearly identify administrative and legal procedures for dealing with violators.

### **III. Institutional Map**

Figure 3 identifies the 3 “aspects” and/or operations involved – ie.:

- Mining
- Processing
- Discharge

It further identifies the institutions and stakeholders from the local to the national levels which are associated with the mining, processing, and discharge aspects of SSGM. The upper half of the page identify, for each aspect, the government (left axis) institutions from local to national level (right axis). The lower half identifies, for each aspect also, the NGO and private sector groups (left axis) from local to national (left axis).

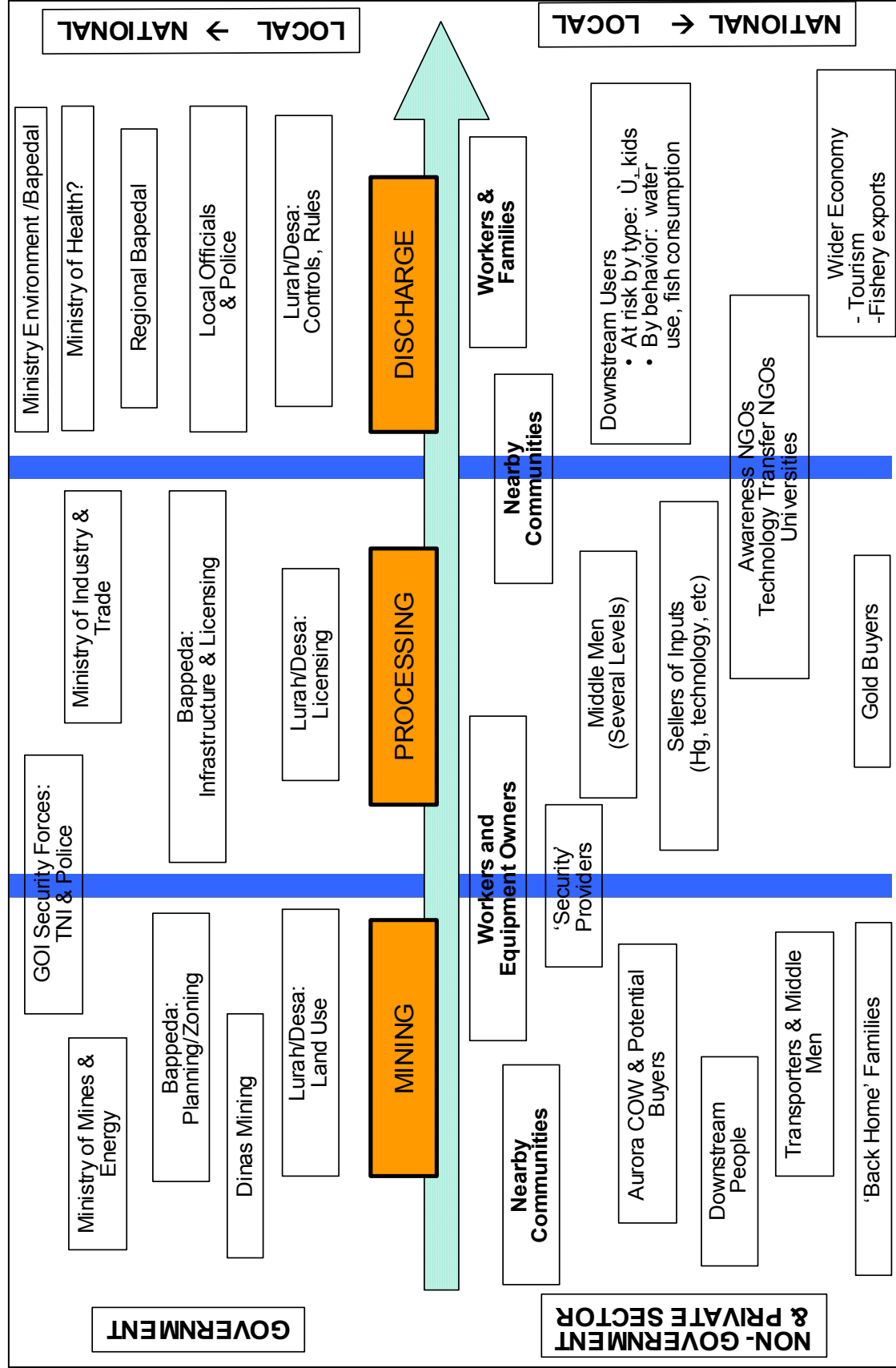
Where government institutions or NGO/private sector groups have activities, responsibilities, and/or activities in multiple aspects of SSGM, they are indicated by the “boxes” crossing the “vertical” lines separating the mining, processing, and discharge aspects of SSGM.

What is not shown is the “relationship and interactions” between all of them – i.e, between government institutions within each and between the different aspects of SSGM. Similarly, the

interaction and relationship between government, NGO and private sectors are not indicated. The brief period for the assessment did not provide the time needed to understand details of the interaction and an analysis of whether the present institutional infrastructure(s) are adequate. It is recommended that this activity be made undertaken.



**Figure 3 - Hg IN SSGM: MAP OF INSTITUTIONS & STAKEHOLDERS**



#### IV. Potential Interventions

Integrated approach to reduce the use of mercury in SSGM's operation is crucial. Coordinated participation of all whose concern at all stages in the development and implementation of policies and programs should be encouraged. Discussing mitigating measures which could involve any or all of economic, technical, legal, health, social and institutional aspects without capacity and capability building of stakeholders, will not be effective in the long run.

From the Team members' perspective, the profile of this issue should be raised. The recommended interventions below basically involve facilitation activities in the following:

1. ***Development of Economic information and Incentives*** for effecting technological change(s) which are needed if introduction of Hg (from SSGM activities) into the environment is to be stopped or minimizing its introduction to the environment is the goal. There will be a need to:
  - Show the economic/cost benefit of technological change(s).  
Develop more specific economic data and information (work closely with the entrepreneur who is carrying out pilot scale studies) on use of cyanide for processing "tailings from SSGM using the Hg-Amalgamation process".
  - Facilitate technology transfer by disseminating information about:
    - Technical processes, equipment, laboratory, training, human and financial resource needs, etc.
    - Organizational changes that would be necessary for some scenarios. Investigate and develop options, data and information on the legal, economic and administrative aspect and/or requirements of forming Cooperatives and Associations
  - Facilitate development of SSGM as an economically and environmentally viable business if it is desired by the community and or the local government authorities.
  - Explore the benefits of following up on PT Newmont's desire to transfer rights to the use of the concentrator they have been piloting for application to SSGM. However, they will only do it if there is a group (government or non-governmental) or person(s) willing to take the project and the responsibilities associated with it
2. ***Legal & Regulatory*** interventions develop and to effectively implement and enforce policies and programs involving:

- Permitting/licensing for
  - Mining operations
  - Processing operations
  - Zoning – i.e., designating “localized” areas where SSGM activities would be permitted, nowhere else.
  - Mercury/cyanide trade
- Property Right Issues
- Level of governance: Roles & Responsibilities
- Cross Institutional Coordination & Communication
  - Output: Consensus building
- Imposition of “Standards for Occupational Health and Safety”

### **3. Cultivate civic responsibilities and participation on mercury problems**

- Mass communication program:
  - use IEC (Information, Education and Communication) material which promote responses that lead to community discussion and learning;
  - making sure that mercury related information is available when people need it. Disseminate clear and concise information regarding mercury to avoid as much as possible the circulation of misinformation and myth.
  - and “put mercury related issues on the agenda”, or draw people’s attention to new issues through mass media.
- Facilitate community discussion amongst stakeholders through town hall meeting and focus group discussion so that they learn together how they will best respond to mercury issue within their own settings and supporting process through which people can build consensus about what to do.
- Working with local NGOs to conduct a process of sequential networking (going from house to house) or small group meetings, identifies opinion leaders and resource person who can help the process for solving the problem.
  - Awareness campaign to the public, and particular the villagers immediately affected by mercury pollution, to understand more precisely their risk of poisoning via mercury vapors or the consumption of food stuffs originating in the mining/processing area.
  - Facilitate involvement of Dinas Kesehatan (Puskesmas, Kabupaten and Propinsi) especially develop the capacity of medical staff in diagnosis of clinical symptoms of mercurialism and to provide sound medical advice to those affected. Involvement of

Dinas Kesehatan on awareness campaign is also crucial because medical doctor were still seen as personnel they could believe.

- Adopt NRM experiences from Kubar, Bunaken and Tondano activities such as zoning, participatory mapping and multi-stakeholder management that can increase community involvement, commitment and public accountability.

#### **4. Further investigate institutional infrastructure for dealing with mercury-related issues from SSGM and clarify roles and responsibilities**

This rapid assessment developed a rough institutional map (Figure 3), but did not have time to study and understand in-depth all the institutional responsibilities and the inter-relationship of the long list of stakeholder involved. More work could be done to clarify and detail the current institutional map, as a basis for informing and educating the stakeholders both governmental and others. This could be used for identifying gaps in knowledge or responsibilities and identifying needed roles, authorities, responsibilities, or advocacy activities. Identifying needs in this way would be a step toward developing a clearer set of institutional relationship with fewer gaps in important functions, the “desired” institutional map.

**Facilitation**, as defined and used here, goes beyond just supporting meetings, seminars, workshop by providing financial and administrative assistance. It means active and participatory involvement by preparing information, materials, and making presentations on technical, legal, administration topics.

- There is, for example, a request from the Provincial level of Governance in Sulut to assist in preparing Guidelines, procedures, rules, etc... related to information of Cooperatives and Associations in SSGM.
- From trommel and processing owners and operators, there is a request for information (technology, economics) on use of the cyanide process in SSGM

#### **5. Investigate the “mercury trade” issue**

The team members did not have time to investigate the “Hg trade” issue but recommend that it be pursued. Prohibiting illegal sale of Hg, as is the case presently, could play a significant role in effecting a technological change.

